Working With Nature To Keep the Chesapeake Healthy

The Chesapeake Bay is an aquatic wonder—a mixture of fresh and salt water from the Atlantic Ocean. Beneath the surface, the variety of species is evident in the oysters, blue crabs, and striped bass, and the submerged plant life that makes up their habitat. However, the environment above water has changed greatly over time. The 64,000-square-mile Chesapeake Bay watershed, originally home to Native Americans and later to the few English settlers who arrived in 1607, now has more than 15 million residents. It encompasses parts of Maryland, Virginia, Pennsylvania, the District of Columbia, and New York State. Everyone who lives in the watershed is just a few minutes from one of the more than 100,000 streams and rivers draining into the bay.

Since colonial times, much of the land surrounding the bay has been used for agriculture. In modern times, this has led to fertilizers and pesticides making their way into the Chesapeake Bay, where they alter the natural balance of flora and fauna. Excess nutrients, such as nitrogen and phosphorus, in its waters have led to outbreaks of bacteria, areas of greatly reduced aquatic biodiversity, and a decline in water quality.

Thanks, in part, to improved agricultural practices over the past 30 years, the Chesapeake Bay is recovering, but more must be done to restore its health. ARS researchers like soil scientist Gregory McCarty and his colleagues at the Environmental Quality Laboratory in Beltsville, Maryland, are looking at ways to reduce damage to the bay from agricultural sources and return the great body of water to its former glory.

Specifically, the team is investigating the design and function of riparian systems, which serve as buffer zones between bodies of water and agricultural fields or urban areas. Riparian zones consist of grasses, forest vegetation, and combinations of plants that slow runoff of contaminants into surface waters and groundwater.

In most states, riparian systems of some sort are being used to improve water quality and provide wildlife habitats. They also help control flooding and sediment movement. But just which types and sizes are most effective? Much of the previous research on this subject has focused on just one or two aspects of a riparian ecosystem. But McCarty's work looks at a riparian system as a whole to see how different processes interact and affect the overall function of the ecosystem.

McCarty's research was conducted at the Beltsville Agricultural Research Center. It's part of a first-order agricultural watershed with a well-defined riparian zone in the Maryland coastal plain. A first-order watershed is an area of land that drains into a stream with no tributaries feeding it. The site was typical of farmland in the area.

STEPHEN AUSMUS (K9991-1)

Hydrologist Jonathan Angier collects groundwater beneath a Beltsville, Maryland, riparian zone to analyze it for dissolved gas content.

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To determine whether denitrification is occurring at a riparian zone, soil scientist Gregory McCarty prepares to measure concentrations of dissolved gases in water samples.

From the Field to the Stream

Nitrogen is mainly transported through groundwater, while phosphorus is mostly carried by surface runoff. Vegetated riparian buffers are often cited as areas where nitrogen and phosphorus can potentially be removed. Riparian systems closest to the field are considered particularly effective at nutrient removal. But, cautions McCarty, "The capacity for riparian systems to slow down or reduce movement of agricultural contaminants is highly variable, both by location within the watershed and time of year. Climate, vegetation, topography, and hydrology exert strong influences on riparian buffer function and behavior, Riparian zones consist of grasses, forest vegetation, and combinations of plants that slow runoff of contaminants into surface waters and groundwater. ARS scientists are studying these natural buffer zones with the goal of keeping agricultural fertilizers and pesticides out of the Chesapeake Bay.

and so affect the contaminant-removing capabilities of a site."

Hydrologist Jonathan Angier, also of the Environmental Quality Laboratory, is studying the effect of hydrology, or water movement through a system, on the effectiveness of a buffer. Water moves not only across the land surface, but also vertically between the surface and the groundwater table. Movement across the soil surface can be decreased by plants and topography. Under the surface, water can move horizontally and vertically, making it more difficult to track and monitor and allowing it to bypass conditions that could potentially help remove contaminants.

Water also moves via first-order streams, the smallest streams in most water systems. Alongside these streams may be large holes, called macropores, which act as a bypass for groundwater, nutrients, and pesticides to travel from beneath the wetland soil directly into the stream.

"Macropores can be created by animals burrowing through the ground or by water pressure," says Angier.

McCarty and Angier constructed sampling stations at five points along a stream to monitor and compare individual stream segments. The segments were each 300 meters (985 feet) long. The field site also included equipment to measure groundwater levels and water pressure.

They found that in the upstream portion of the wetland, the water-saturated conditions within the floodplain were caused by groundwater rising to the surface, not by stream flooding. Generally, the faster the groundwater reaches the surface, the more nitrogen it likely contains. "This consequently influences how much nitrogen makes it to area streams," says Angier—and ultimately to the larger ecosystem, in this case the Chesapeake Bay.

Riparian buffers, even in their least effective portions, do remove significant portions of groundwater nitrate. But their overall efficacy is greatly influenced by hydrological conditions. Since some parts of the system may be more effective at nutrient removal than others, "A one-size-fits-all approach may not be sufficient to maximize the remediation potential of these systems," Angier says.

Where Nutrients Rest, Carbon Deposits

Riparian buffer zones have another benefit: They may allow more carbon to be stored in the soil.

"Nutrient inputs into wetland systems can increase growth of riparian vegetation, and this growth may represent a substantial increase in carbon storage capacity," says McCarty. "Carbon, stored as organic matter in the soil, makes the ecosystem more fertile and helps the plants and soil microorganisms remove excess nutrients from the water."

Erosion and soil deposition associated with agricultural activity can increase carbon storage within landscapes, including riparian buffers. Testing of samples of deposited sediments in the riparian zone determined that agricultural activity in the watershed has caused increased sediment deposition to the wetland. "In the past 45 years or so, upland sediment has become highly enriched in organic matter, indicating that large amounts of organic carbon have been stored there," says McCarty. “Rates of carbon sequestration in the wetland are much higher than rates that occurred before agricultural activity began in this watershed.”

McCarty concludes, “Our studies on a small agricultural watershed indicate that sediment deposition makes the wetland more efficient for storing carbon.”

As for the Chesapeake Bay, riparian systems seem to be able to alleviate the major stresses on it—excess nutrients from agriculture, other forms of water pollution, and changes in the landscape from development and erosion. The challenge for future research will be to determine the best design for these systems, taking into account the role that water movement through the soil plays in their effectiveness.—By **Sharon Durham,** ARS.

This research is part of Soil Resource Assessment and Management, an ARS National Program (#202) described on the World Wide Web at http://www.nps.ars.usda.gov.

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Soil core taken from a Beltsville, Maryland, riparian zone at about 6 feet deep. The dark matter represents the bottom of the riparian soil zone. The light-colored matter, taken from a deeper depth, is from the top of a water-bearing aquifer.

STEPHEN AUSMUS (K9993-1)

Clusters of piezometers with gauges to continuously measure water levels are placed amid various types of vegetation, like the skunk cabbage shown here, which potentially reduce surface and groundwater contaminants.